

## CLAIMS

- 1    1.      Apparatus comprising
- 2                a portable electronic device,
- 3                a digital camera associated with the portable electronic
- 4                device, and
- 5                software configured to run on the portable electronic device
- 6                and to derive handwriting and control information from hand
- 7                motion of a writing instrument in the vicinity of the digital camera.
- 1    2.      The apparatus of claim 1 in which the portable electronic
- 2                device comprises a mobile telephone or a personal digital assistant.
- 1    3.      The apparatus of claim 1 in which the digital camera is
- 2                attached to the portable electronic device.
- 1    4.      The apparatus of claim 1 in which the digital camera is
- 2                incorporated in the portable electronic device.
- 1    5.      The apparatus of claim 1 also including an infrared filter
- 2                arranged to filter light being received from the writing instrument.
- 1    6.      The apparatus of claim 1 also including a lens arranged to
- 2                alter the focal length and/or depth of field of the digital camera.
- 1    7.      The apparatus of claim 1 also including a mechanism
- 2                configured to enable the digital camera to be attached to a writing
- 3                surface.

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1       8.       The apparatus of claim 7 in which the mechanism  
2       comprises a suction device configured for attachment to a white  
3       board.

1       9.       The apparatus of claim 7 in which the mechanism  
2       comprises a clip configured to grasp paper.

1       10.      The apparatus of claim 7 in which the portable electronic  
2       device includes a writing surface.

1       11.      The apparatus of claim 10 in which the writing surface is  
2       on a protective cover.

1       12.      The apparatus of claim 1 in which the software is  
2       configured to define a mapping between a sensor surface in the  
3       digital camera and a space in which the hand motion is occurring.

1       13.      The apparatus of claim 1 in which the software is  
2       configured to define the mapping in response to calibration steps  
3       that include a user marking three locations in the space in which  
4       the hand motion is occurring.

1       14.      The apparatus of claim 1 in which the software is  
2       configured to derive the location and trajectory of the hand motion.

1       15.      The apparatus of claim 1 in which the software is  
2       configured to generate the handwriting and control information  
3       based on processing cycles each associated with one location of the  
4       writing instrument.

1       16.      The apparatus of claim 1 in which the software is  
2       configured to discriminate light received from the writing

3 instrument by locking onto a carrier frequency at which light from  
4 writing instrument is modulated.

1 17. The apparatus of claim 1 in which the software is  
2 configured to determine a tilt of the writing instrument relative to a  
3 direction normal to a writing surface.

1 18. The apparatus of claim 1 in which the portable electronic  
2 device includes a display and the trajectory of the hand motion is  
3 shown on the display in real-time.

1 19. The apparatus of claim 18 in which the display is not  
2 touch-sensitive.

1 20. The apparatus of claim 1 in which the portable electronic  
2 device includes a digital signal processing chip and a general  
3 purpose microprocessor and the software is run in part on the chip  
4 and in part on the microprocessor.

1 21. The apparatus of claim 1 in which the portable electronic  
2 device includes a wireless communication facility and the software  
3 is configured to communicate the handwriting and control  
4 information to a remote location.

1 22. The apparatus of claim 1 in which the digital camera is  
2 configured to receive light that has been reflected from the writing  
3 instrument.

1       23.     The apparatus of claim 1 in which the digital camera  
2     comprises a still camera.

1       24.     The apparatus of claim 1 in which the digital camera  
2     comprises a video-capable camera.

1       25.     The apparatus of claim 1 also including an infra-red beacon  
2     configured to be directed at the writing instrument.

1       26.     The apparatus of claim 1 in which the software is  
2     configured to apply pattern recognition to signals from the digital  
3     camera.

1       27.     A method comprising

2              exposing a sensor of a digital camera to a writing  
3     instrument that is being subjected to hand motion, and

4              in a device associated with the digital camera, processing  
5     the data to infer handwriting and/or control information based on  
6     the hand motion.

1       28.     The method of claim 27 in which the exposing of the  
2     sensor includes receiving light that originates from light sources on  
3     the writing instrument.

1       29.     The method of claim 27 in which the exposing of the  
2     sensor includes exposing the sensor to a trace or other marking left  
3     by the writing instrument.

1       30.     The method of claim 29 in which the trace or other marking  
2     includes ink selected to increase a signal-to-noise ratio of light  
3     received by the sensor.

1       31.     The method of claim 27 in which the exposing of the  
2     sensor includes processing of an image of a tip of a writing  
3     instrument.

1       32.     The method of claim 31 in which the tip of the writing  
2     instrument is characterized by being of high contrast with the  
3     environment in which it is used.

1       33.     The method of claim 27 in which the sensor is exposed to  
2     hand motion occurring with respect to any arbitrary surface at any  
3     arbitrary angle.

1       34.     The method of claim 27 also including  
2                  calibrating the digital camera in a manner to permit  
3     correctly inferring linear hand motions.

1       35.     The method of claim 27 also including calibrating the  
2     processing of data using information derived when the writing  
3     instrument is touched to at least two points on a writing surface.

1       36.     The method of claim 27 also including automatically  
2     switching the digital camera from one format to another by  
3     coupling the camera, or a device to which it is connected, to  
4     another mechanism.

1       37.     The method of claim 27 also including adjusting a tilt  
2     and/or swivel position of the camera for better coverage of a  
3     writing surface.

1       38.     The method of claim 27 in which light sources on the  
2     writing instrument are operated to enabling filtering of noise and  
3     interference.

1       39.     The method of claim 27 in which light sources on the  
2 writing instrument are sequenced to encode functionality that  
3 includes at least one of erasing or biometrics of handwriting.

1       40.     The method of claim 27 in which there are enough light  
2 sources associated with the writing instrument to prevent loss of  
3 tracking when one or more of the light sources are blocked.

1       41.     A method comprising  
2                 using a two-dimensional sensor in a digital camera to  
3                 permit subpixel calculations of a position of a writing instrument  
4                 that is in the field of view of the camera,  
5                 averaging lines, and  
6                 applying an algorithm to derive a final position from the  
7                 averaged lines.

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